The Effects of Technical Skills, Attitudes, and Knowledge on Students' Readiness to Use 4.0 Industrial Revolution Technologies in Education

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To cite this article:

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Article Info	**Abstract**
	Technological advancements have led to the emergence of the Fourth Industrial Revolution (4IR). Students' readiness to use 4IR technologies is thus essential for the development of knowledgeable, competent, and skilled graduates. However, ensuring students' readiness to use 4IR technologies is quite challenging, leading to a need to understand the factors that influence readiness in this regard. In this study, a research model was developed for examining effects of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies. Data were collected from 182 students through an online survey. A two-step data analysis was then performed using AMOS. A confirmatory factor analysis was conducted to assess the research model, and SEM was then applied to examine the hypotheses and relationships between the constructs. The results demonstrated that students' technical skills, attitudes, and knowledge levels significantly influenced their readiness to use 4IR technologies. Recommendations for policy and decision makers in higher education were drawn from this research to increase students' readiness for adopting and using 4IR technologies.

Introduction

The technological advancements, such as blockchain, artificial intelligence, robotics, cloud computing, data science, virtual reality and 3D printing, have led to the emergence of the Fourth Industrial Revolution (4IR) (Kuruczleki, 2012; Guangli et al., 2018). Technology has facilitated changes in people's economic and social lives, resulting in the disappearance of some jobs and the establishment of others (World Economic Forum, 2022). Thus, the knowledge and skills of the workforce must be updated and upgraded to maintain jobs in the 4IR era.

Higher education institutions carry the responsibility of developing the knowledge and skills of future generations. Lamprini and Butler-Adam (2018) stated that innovation, creativity, and learning for life are necessary for skilled workers and learners in the 4IR era. Institutions of higher education thus need to respond to the quick development of technologies and innovations by updating their plans and programmes and offering new approaches that meet demand of knowledgeable and skilled graduated students who could deal and cope with 4IR era. Institutes and universities need to work on producing dynamic graduated students who possess critical-thinking, cognitive skills

and problem-solving (Gleason, 2018). It is essential for institutions to deliver the right skills and knowledge by reflecting on how students are influenced by the 4IR and determining achievable changes and transformations in education. It is important to adopt new educational approaches, as the old ways are no longer relevant, and accept changes and innovations as necessary to survive. 4IR has been altered and will be continued, and it will affect several aspects of education such as research, teaching, resources/services, laboratories, virtual teachers, virtual classes and libraries (Xing & Marwala, 2017; Mian et al., 2020).

Countries need to prepare their citizens to work and live in the era of 4IR. Institutions in higher education play a big role to handle this technological shift and have a responsibility to update the education process and prepare graduates for 4IR requirements and technologies (Gordon, 2016). Furthermore, university graduates have to be flexible, well-informed, capable to learn and relearn, prepared for facing challenges due to automation, and capable to get advantages of any related chances (Penprase, 2018).

To produce skilled graduated students who could contribute to workforce, it is necessary to examine students' readiness for 4IR. Knowing what factors could influence students' readiness can help higher education institutions determine the skills and knowledge that graduates need to gain in the 4IR era; thus, higher education institutions can also be facilitators for training other industries and private institutions (Ujakpa et al., 2020). However, there is a lack of research that focus on students' readiness toward using 4IR in some developing countries. Ismail et al. (2020) highlighted the need for a framework model that can help identify students' readiness toward using 4IR. Thus, this study aims at building a framework for investigating the various elements that influence students' readiness to use 4IR technologies, specifically by examining the effects of students' technical skills, attitudes, and knowledge on their readiness for the 4IR in education. The study findings will benefit higher education institutions and their administrations as well as industry and society since they would be informed about the factors that may influence learners' preparation for 4IR technologies. Accordingly, they can focus on these factors to increase students' skills and knowledge and to ensure their readiness for the 4IR.

Literature Review

Readiness is defined as preparation level required to fulfil a duty that leads to meaningful learning and development (Hayes & Stratton, 2013). Vakola (2013) defined readiness as a cognitive precursor of behaviour that results in change efforts, support, or resistance. Thus, to enhance students' understanding of 4IR technologies and their uses in education, institutions need to assess students' readiness and the factors that may affect readiness and, accordingly, build convenient education programmes and provide the required training.

Few studies were conducted and focused on assessing students' readiness for the 4IR and what factors that affect readiness. For instance, Motyl et al. (2017) examined 463 students' readiness for the 4IR in three Italian universities. The results revealed the need for an educational model that provides students with structured knowledge. Students were aware about the 4IR, but they had lacked knowledge on applying 4IR technologies in real-life contexts. It was also found that most universities did not enhance students with opportunities that develop their knowledge and understand the ways to implement 4IR technologies. Thus, most students have unprepared

feeling for joining workface in the 4IR era. Higher education institutions need to increase their efforts to ensure students' readiness toward using 4IR by enhancing their understanding of the many factors that affect readiness.

There are several challenges that education sectors face in adopting 4IR technologies, specifically in development of teachers, pedagogical adaptation, infrastructure, insufficient fund, and also skills of graduated students to deal with technological developments (Kayembe and Nel, 2019). Ahmad et al. (2019) examined the readiness of 200 students toward using 4IR at a university in Malaysia. Results showed that most of students were able and ready for applying their technical skills, obtaining knowledge, and also adapting to some changes due to 4IR advancements. Although most students had some skills relevant to the 4IR, for instance, skills of leadership and communication, they needed to develop their skills to solve problems without receiving assistance, especially those problems associated with technology. Ismail et al. (2020) assessed the preparedness of 136 students of vocational education at a technical Malaysian university and they found out that the knowledge of students about 4IR was weak, even though their interest in the same was high. The researchers asserted that the university must hold more training programmes, seminars, and forums for raising the awareness of students about 4IR.

Tinmaz and Jin (2019) conducted a study to measure 129 students' knowledge of the 4IR in South Korea. Results revealed that the students had heard about the 4IR but were unaware of related applications in real life. The students stated that even though they knew of and commonly spoke about the 4IR, they were lacked in a deeper conceptual understanding about its implementation and applications. They assumed that it may be because of the lack of specialized training programmes that address the uses and implications of 4IR technologies in institutes of higher education in South Korea.

Puriwat and Tripopsakul (2020) assessed 132 students' readiness to adopt 4IR technologies for learning In Thailand. The findings revealed a lack in students' information and digital skills, which are needed for the 4IR era. The researchers recommended reforming the education system in Thailand and taking the actions needed for preparing students for the 4IR era, for example, providing programmes which develop students' knowledge of 4IR technologies and their utilization in their real-life scenarios. In addition, Ujakpa et al. (2020) qualitatively examined the preparedness of 24 students in Namibia. Findings showed that students were aware of the 4IR, but they required further education on the uses and applications of new technologies to be prepared to work with them. The researchers recommended that higher education institutions and concerned governmental bodies establish strategies and approaches for creating more awareness about 4IR advancements, especially in their applications.

Several factors may affect students' readiness for the 4IR. Halim et al. (2019) mentioned that learners in Malaysia require various skills, such as creativity, communication, critical thinking, and collaboration, to be ready and prepared for the era of the 4IR. Rampasso et al. (2020) mentioned that many characteristics can affect students' readiness for the 4IR, such as digital literacy, leadership, communication, and decision-making. Eleyyan (2021) examined the readiness of 77 preservice teachers regarding the implementation of 4IR technologies in education in Oman. The findings showed that preservice teachers need to gain technical, coordination, time management, critical thinking, and verbal skills in communication to be able and prepared for the 4IR. According to Ismail et

al. (2020), there is a need for a framework model that identifies students' readiness and the factors that affect their readiness for the 4IR. Thus, the aim of this study was to create a framework for investigating the various elements that influence students' readiness to use 4IR technologies, specifically by examining the effects of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies in education. The research hypotheses are given below:

H1: Technical skills have positive effects on students' readiness to use 4IR technologies.

H2: Students' attitudes have positive effects on their readiness to use 4IR technologies.

H3: Knowledge has a positive effect on students' readiness to use 4IR technologies.

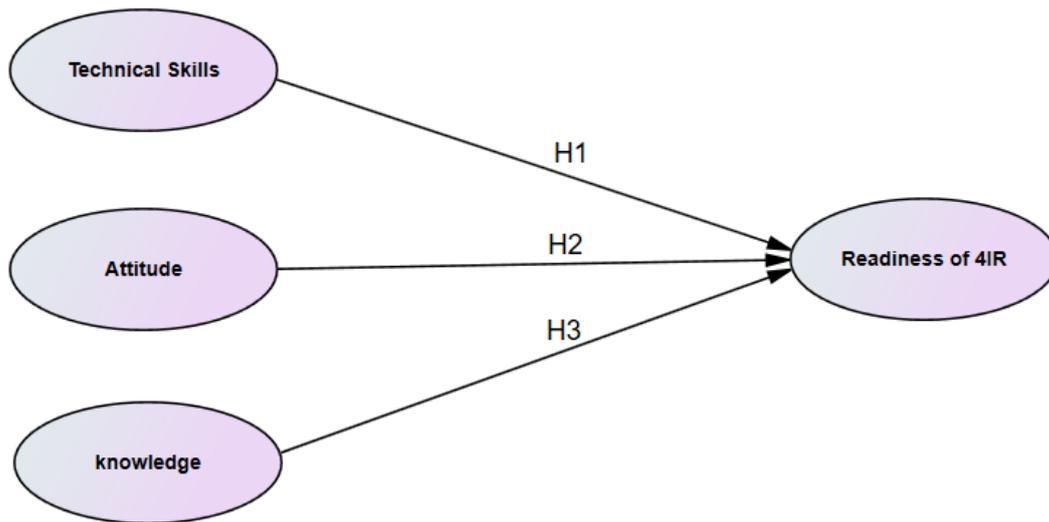The suggested proposed model is presented in Figure 1.

Figure 1. Research Model

Methodology

Research Design

The design of this current study was entirely quantitative and applied a survey for gathering data from targeted population. Quantitative research involves the collection of numerical data to describe a phenomenon. To analyse this data, mathematical approaches and statistical techniques must be applied (Creswell, 2013). Furthermore, Kumar et al. (2008) asserted that the quantitative approach is objective, formal, and systematic, which assists in describing and testing the causes and relationships among constructs. For purpose of this current study which is to assess the influence of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies in education – the quantitative approach was deemed the most convenient.

Procedure and Participants

A two-part online questionnaire was used to gather the data. The first part focused on the demographic information of the respondents, including gender, year in college, and whether the student attended training workshops related

to the 4IR. The second part contained 24 items that measured the constructs in the proposed research model. Google Forms was used to create the survey, which was then distributed at random to around 195 students in college of education at the University of Ha'il during the second semester of 2022-2023. In all, 182 students participated and responded to the survey, following which a data analysis was conducted. The response rate was 93%, and the data were deemed convenient for analysis. According to Hair et al. (2014), the minimum size of a sample should be between 100 and 200 to be considered appropriate. The sample size for this study was 182, which met the above suggestion. Prior to conducting this study, ethical approval was received from the Committee of Research Ethics at the University of Ha'il.

Instrument

The survey consisted of two major sections. The first part, which focused on the respondents' demographic information, was self-designed. The second part consisted of 24 items that were modified and adapted from previous studies. These items measured the impact of technical skills, attitudes, and knowledge on students' readiness. The items for the technical construct were adapted from Ahmad et al.'s (2019) study, those that measured attitudes were adapted from Ismail et al.'s (2020) study, those that measured the knowledge construct were adapted from the studies of Tinmaz and Jin (2019) and Ujakpa et al. (2020). The items for readiness constructs were adapted from a study of Ahmad et al.'s (2019) study. All questions for measuring the constructs are attached in appendix.

Results

A total of 182 students responded to the survey. Table 1 shows demographic information of respondents. With regard to gender, most students were male (39; 51.1%), and the remaining were female (89; 84.9%). In terms of their year of study, 61 students were in their first year (33.5%), followed by 41 students in their third year (22.5%) and 16 students in their fifth year (8.8%). With regard to workshops on 4IR technologies, most students reported that they had not attended any workshops (155; 85.2%), and only some had attended such workshops (27; 14.8%).

Table 1. Respondents' Demographic Information

		Frequency	Percent
Gender	Male	93	51.1
	Female	89	48.9
Year	First	61	33.5
	Second	35	19.2
	Third	41	22.5
	Fourth	29	15.9
	Fifth	16	8.8
Attended Workshop	No	155	85.2
	Yes	27	14.8

Structural Equation Modelling

Confirmatory Factor Analysis (CFA)

CFA is considered the best method for developing a measurement model because of its power in considering the different types of correlations among constructs and dealing with measurement errors (Awang, 2015). Many constructs can be considered for treatment together, and constructs with limited items can be included (Awang, 2015). In a CFA, a measurement model is assessed in terms of its constructs and convergent and discriminant validity (Hair et al., 2014; Awang, 2015). Construct validity is achieved when all fitness indices meet the levels suggested in the literature. A CFA was conducted, and some items were eliminated because of low factor loadings (ex knw1, KW2, ATT6, ATT1, SR2). Then, the CFA was assessed. The output is shown in Figure 2.
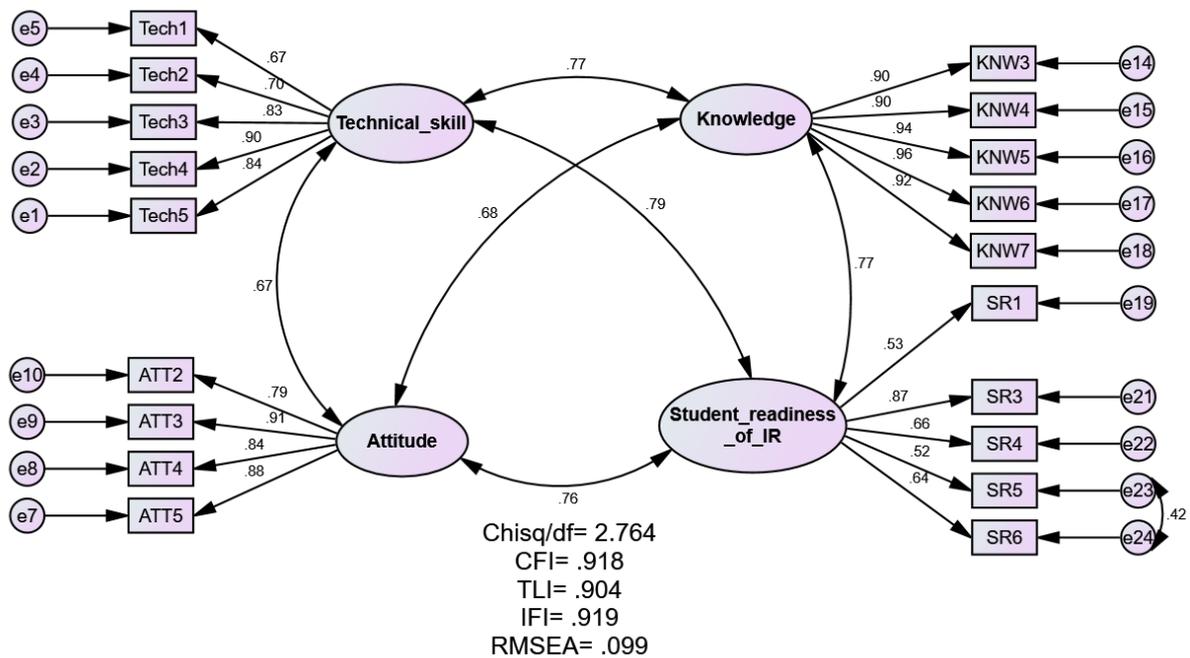

Figure 2. Pooled CFA

According to Hair et al. (2014) and Awang (2015), once all construct indices reach specific levels, construct validity is attained. In the present analysis, the values of all model indices exceeded those values recommended by the earlier researchers; thus, construct validity was attained. Table 2 presents the construct indices that reached the suggested levels.

Table 2. The Model Indices

Category	"Index"	"Index value"	"Level of acceptance"	"Decision"
"Absolute fit"	RMSEA	0.99	< 1	Attained suggested level
"Incremental fit"	CFI	0.918	> 0.90	Attained suggested level
	TLI	0.904	> 0.90	Attained suggested level
	IFI	0.919	> 0.90	Attained suggested level
"Parsimonious fit"	Chisq/df	2.764	< 3.0	Attained suggested level

Then, validity of convergent and discriminant had to be evaluated before applying SEM to analyse the path and test the research hypotheses. Convergent validity is met when the value of composite reliability (CR) is higher than 0.6 and the average value extracted (AVE) is higher than 0.5 (Awang, 2015). CR and AVE were above the suggested values in the present study, indicating that convergent validity was attained. Table 3 displays the CR and AVE outcomes.

Table 3. CR and AVE Results

	CR	AVE
Knowledge	0.967	0.856
Technical skill	0.894	0.631
Attitude	0.917	0.736
Student_readiness__of_4IR	0.783	0.529

Finally, discriminant validity was then assessed. To attain discriminant validity, the values in **Bold** which represent the square root of AVE and shown in Table 4, had to be higher than all other values in the associated rows and columns (Awang, 2015). As demonstrated in Table 4, all the required values (given in bold) were higher than other values (in the same column and row), demonstrating discriminant validity.

Table 4. Discriminant Validity

	Knowledge	Technical_skill	Attitude	Student_readiness__of_4IR
Knowledge	**0.925**			
Technical skill	0.769	**0.795**		
Attitude	0.684	0.672	**0.858**	
Student_readiness__of_4IR	0.769	0.785	0.764	**0.835**

Standardized Estimates

When structural equation modelling is run, it generates standardized and unstandardized estimates as two different outputs. Standardized estimates are utilized to assess the factor loadings of items, R2, and the beta coefficient, whereas unstandardized estimates are used to assess regression weight, critical ratio, and the testing hypothesis. The results of the standardized estimates in the present study are displayed in Figure 3.

R2, a standardized estimate, was 74%, indicating that the construct of students' readiness could be explained by the three independent factors, namely technical skills, attitudes, and knowledge. This result also showed that the model had a high level of explanatory power. Cohen (1988) stated that R2 ≤ 0.12 indicates the low explanatory power of a model, values from 0.13 to 0.25 indicate medium explanatory power, and values above those indicate strong explanatory power. R2 for the proposed model was 0.74, demonstrating that the research model had strong explanatory power – that is, to explain which factors affect the construct of students' readiness to use 4IR technologies.
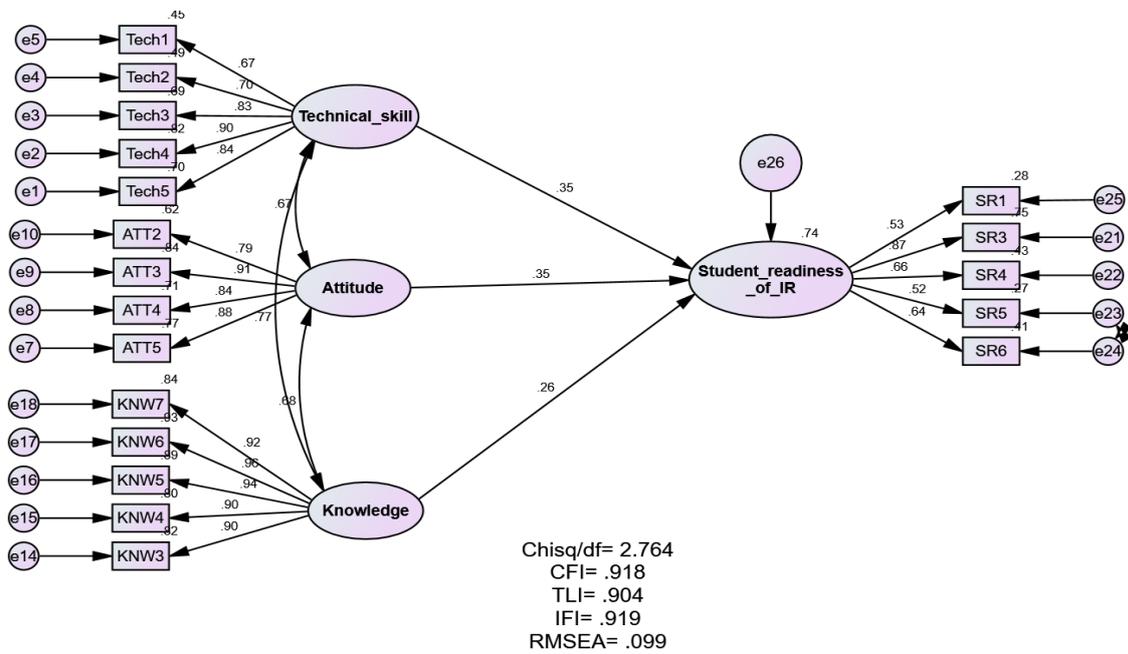
Figure 3. Standardized Estimates

Unstandardized Estimates

Unstandardized estimates are essential for unstandardizing the beta estimate and regression weight and for assessing the critical ratio of the testing hypotheses. The output for the unstandardized estimates in the present study is shown in Figure 4.
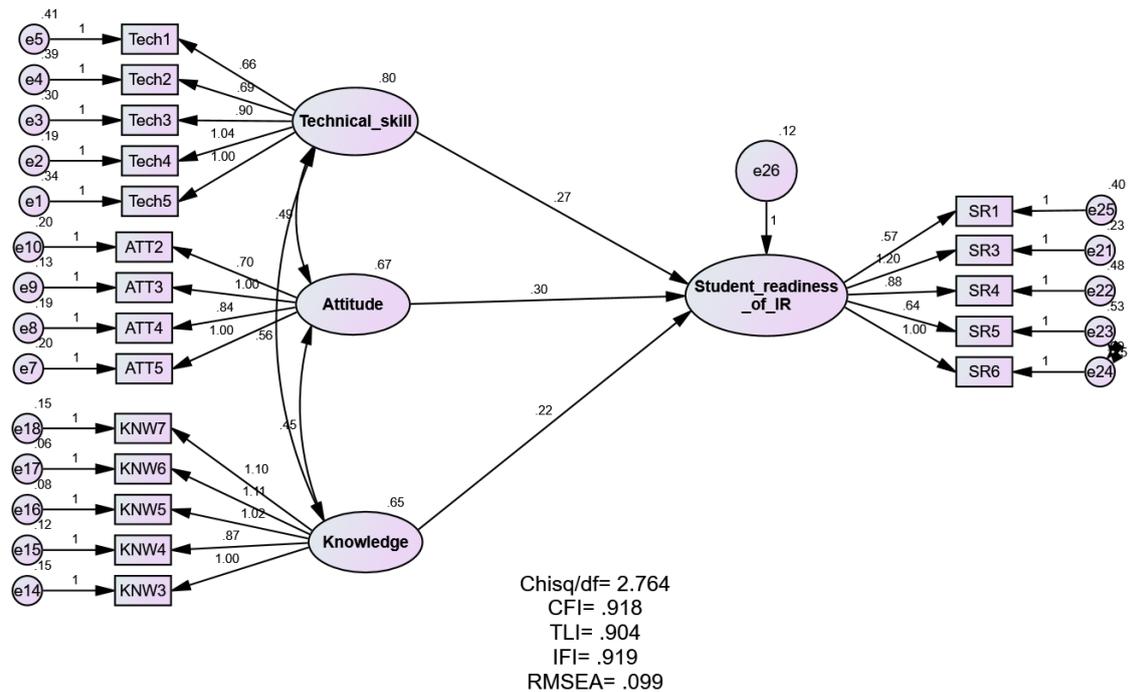

Figure 4. Unstandardized Estimates

The results (see Table 5) revealed that technical skills, attitudes, and knowledge had significant positive effects on students' readiness to use 4IR technologies ($\beta = 0.269$, $p < 0.05$; $\beta = 0.296$, $p < 0.05$; $\beta = 0.224$, $p < 0.05$, respectively). Thus, H1, H2, and H3 were supported.

Table 5. Hypothesis Testing

			Estimate	SE	CR	P	Results
Student_readiness__of_4IR	<---	Technical_skill	0.269	0.079	3.393	***	Supported
Student_readiness__of_4IR	<---	Attitude	0.296	0.075	3.951	***	Supported
Student_readiness__of_4IR	<---	Knowledge	0.224	0.083	2.691	.007	Supported

Discussion

This study examined the effects of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies in education. The findings showed that technical skills positively influence the students' preparedness for 4IR technologies (B = 0.269; P < 0.05). This is in line with the findings of previous studies (e.g., Juwita et al., 2020; Alshammari, 2020; Matsepe & Lingen, 2022). Students with high technical skills are more likely to adopt and use 4IR technologies for learning. Thus, technical skills and training are essential for the adoption and use of 4IR technologies. Universities and institutes should focus more on developing students' skills and providing them with the necessary training to develop the technical skills required to use 4IR technologies for learning.

The findings also showed that the students' readiness to use 4IR technologies was significantly impacted by their attitudes (B = 0.296; P < 0.05). This is in line with the findings of previous studies (e.g., Sánchez & Hueros, 2010; Teo et al., 2019; Sembiring et al., 2022). Students with high levels of positive attitudes towards 4IR technologies are more likely to be ready to adopt and use them. Thus, universities and educational institutes should engage students in learning via the use of 4IR technologies in their daily lives; students who gain interest in using 4IR technologies would have greater positive attitudes towards using 4IR technologies than those who remain uninterested.

With regard to students' knowledge, the findings showed that students' knowledge of 4IR technologies had a significant positive effect on their readiness to use 4IR technologies (B = 0.224; P < 0.05). These results are consistent with those of earlier studies (e.g., Tinmaz & Jin, 2019; Ujakpa et al., 2020; Matsepe & Lingen, 2022). High levels of knowledge and awareness were found to have positive effects on students' readiness to use 4IR technologies. Therefore, to prepare students, universities and other educational institutes should provide students with credible resources and introduce them to 4IR technologies. Students' knowledge of 4IR technologies and their use play a crucial role in minimizing the worries that arise from a lack of understanding. Educational institutes and universities should review and restructure their programmes and curricula to provide graduates with greater knowledge of 4IR technologies. It is also essential for academicians to enhance their knowledge and be upskilled and reskilled in 4IR technologies, such as big data, Internet of things and cloud technology, so that they can transfer their skills to their students.

Higher education policymakers and universities' top management should focus on developing students' technical skills, attitudes, and knowledge of the 4IR since these factors have positive impacts on students' readiness to use 4IR technologies in their learning. This means that the management of higher education institutions and universities should plan and launch different initiatives to provide students with the needed aspects of 4IR technologies. Furthermore, higher education institutions should work on their infrastructure and develop labs, smart campuses, and digital libraries and classrooms to generate knowledge and provide innovative solutions to enhance their students' skills and thus prepare them to adopt and use 4IR technologies.

Limitations and Further Research

There are some limitations in the current study. First, a purely quantitative approach was used to investigate the effects of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies. Future research may rely on both quantitative and qualitative approaches for gaining a deeper, more understanding of the effects of these factors on students' readiness. In addition, further studies may consider factors that were not examined in the present study, such as technological infrastructure and management support. While this study examined some factors that impact students' readiness to use 4IR technologies, future studies may focus on assessing the impact of different factors on academics, staff, etc. This study was conducted at one university in Saudi Arabia, and the findings may differ in different contexts. Therefore, conducting a similar study in a different context might be of interest in the future. Even though 4IR technologies offer huge benefits to students, their implementation and preparing students to adopt and use them can be challenging. Thus, studies should focus on how policymakers in higher education and universities can implement 4IR technologies.

Conclusion

This study examined the effects of students' technical skills, attitudes, and knowledge on their readiness to use 4IR technologies. A research model was built, and the hypotheses were examined and tested. The findings showed that students' technical skills, attitudes, and knowledge influenced their readiness to use 4IR technologies. Policymakers in higher education and universities are responsible for preparing students to use 4IR technologies. They need to establish plans for enhancing students' technical skills, positive attitudes towards 4IR technologies, and knowledge of the 4IR. Prioritizing and working on these aspects will affect students' readiness to use 4IR technologies in their learning. Furthermore, students should be allowed to experience 4IR technologies in on-campus environments through smart services and facilities such as 3D and 4D printing, augmented and virtual reality, the Internet of things, and smart classrooms.

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Appendix.

Technical skill

I'm skilled for accessing the internet software and applications which is necessary for searching information.

I'm skilled in word processing which is essential in the 4.0 Industrial Revolution.

I must learn using email regularly for receiving or sending information by adapting the changes toward 4IR.

I'm skilled for accessing spreadsheets for keying in data which is required in 4IR.

I should be skilled technically in dealing with presentations which is useful toward 4IR.

Attitude

The era of 4IR is interested for me.

4IR technologies enhance me to think.

4IR technologies affect daily life.

I'm interested in exploring 4IR technologies.

I'm satisfied with accessing to 4IR technologies environment.

I'm satisfied with communication using 4IR technologies.

Knowledge of 4IR

Data Science

Internet of Things

Cybersecurity and Encryption

Artificial Intelligence

Cloud Computing

Augmented and Virtual reality

Non-Humanoid and Robots.

Student readiness towards 4IR

I'm ready for adapting changes in 4IR technologies.

I'm ready for applying technical skills in required job tasks in 4IR technologies.

I'm ready for learning new information and knowledge provided by 4IR technologies.

I'm ready for doing job tasks with an innovation approach toward 4IR technologies.

I'm ready to change my work style by using 4IR technologies.

I'm ready for attending 4IR technologies training.